

# **PYROTEK COMBUSTION TECHNOLOGY**

**Spark Ignition Electrode  
Advancement and its effect on  
Small Engine Emissions**

# **PYROTEK RESEARCH GOALS**

- **Improve combustion at the source - spark initiation**
- **Realize “Downstream” byproducts of increased power, reduced emissions, and reduced fuel usage**

# PYROTEK ADVANCED ELECTRODE

- Studies performed by Dr. Brereton of the Michigan State University Engine Lab and by Dr. Shelton of the Georgia Institute of Technology
- Preliminary studies reported in SAE paper #982057 (Brereton & Rahi)
- Other studies report the effects of electrode design on combustion: Jost ('96), Witze ('82), Daniels & Scilzo ('96), Witz ('82), Herweg, et al. ('88), Acroumanis & Bei ('92), Maly ('84), Heywood & Pischninger ('90), Hall ('89), Anderson & Asik ('83), Ziegler et al ('86), etc.

# PYROTEK ELECTRODE

- Automotive reference engine studies used to develop advanced combustion technologies
- Combustion improved through the optimization of electrode geometry
- Flame front speed increased
- Combustion temperature increased
- Indicated Mean Effective Pressure increased
- Distinction made between “minimal” combustion and “optimal” combustion

# SMALL ENGINE STUDIES

- Small engine studies indicate performance improvements available through the use of the new geometry
- Faster flame front reaches end-gases for more complete burn
  - Power increase measured
  - Emission reduction statistically significant

# FOUR STROKE ENGINE TESTS

- OHV
  - Power increased an average of 6% across a range of OHV engines tested with the Pyrotek spark plug
  - BSFC reduced an average of 8%
  - Hydrocarbon emissions reduced 6%
  - CO stable between electrode designs
- Side Valve
  - HC emission constant between electrode designs
  - CO reduced 50% with the Pyrotek spark plug
  - BSFC reduced 14%

# TWO STROKE ENGINE TESTS

- Faster flame front and kernel orientation has a particular benefit in two stroke engines
- Emission tests performed on a range of two stroke engines from four leading manufacturers
- EPA 40 CFR Part 90 certification protocol used at Dr. Brereton's MSU laboratories.
- Benefit measured despite unchanged scavenging losses (~30%)

# TWO STROKE ENGINE TESTS

- Brand “A” EPA Phase I Engine
  - Power up 4% when comparing Pyrotek vs. standard design spark plug
  - BSFC reduced 6% using Pyrotek
  - HC reduced 16% using Pyrotek
  - CO reduced 8% using Pyrotek



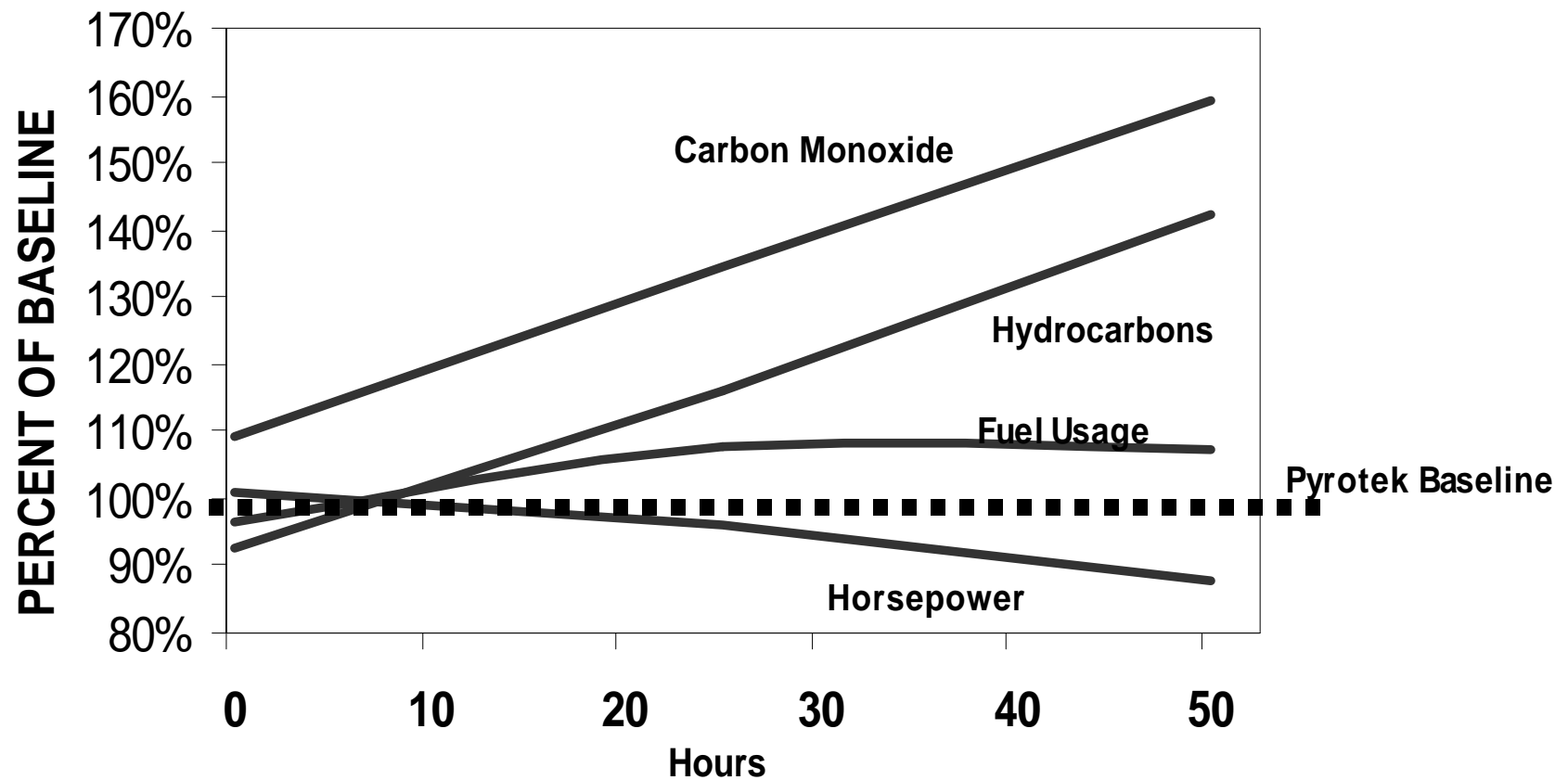
# TWO STROKE ENGINE TESTS

- Brand “B” EPA Phase I Durability Tests
  - 25 Hours
    - Pyrotek spark plug reduces HC by 16%
    - CO reduced by 35% with Pyrotek

# TWO STROKE ENGINE TESTS

- Brand “B” EPA Phase I Durability Tests
  - 50 Hours
    - HC reduced 42% with Pyrotek plug
    - CO reduced 59%
    - Power up 12%
    - BSFC improved 7%
    - Strong reduction in carbon deposits when aged with the Pyrotek spark plug

**SPARK PLUG DURABILITY TEST:**  
**Standard Electrode Performance vs. Pyrotek Baseline**  
**50 Hour Tests Conducted at MSU Engine Research Lab**



# 50 Hour Durability Test

- Standard spark plug promotes typical carbon deposits, pitting, and ring land contamination
- Pyrotek spark plug produces near-new condition after 50 hours



# TWO STROKE ENGINE TESTS

- Brand “B” Retrofit Study
  - Engine aged 50 hours with standard spark plug
    - Carbon deposits evident
  - Pyrotek spark plug inserted
    - HC reduced 5%
    - CO reduced 25%
  - Future HC reductions predicted through the reduction in carbon deposits

# TWO STROKE ENGINE TESTS

- Brand “C” catalytic converter-equipped two stroke engines (Tier II compliant)
  - Pyrotek spark plug increases power 13%
  - BSFC reduced 6%
  - HC reduced 11%
  - CO reduced 10%
  - Catalytic converter HC and oil contamination reduced with Pyrotek plug

# TWO STROKE ENGINE TESTS

- Brand “D” two stroke Tier II engine with high trapping ratio - tested w/o catalyst
  - Power increased 7% with Pyrotek plug
  - BSFC improved 14%
  - HC reduced 11%
  - CO unchanged

# TWO STROKE ENGINE TESTS

- Brand “D” two stroke Tier II engine with high trapping ratio - tested with catalyst
  - 0 Hour
    - HC stable
    - CO reduced 19% with the Pyrotek spark plug
  - 25 Hours
    - HC reduced 13% using the Pyrotek plug
    - CO reduced 82%



# TWO STROKE ENGINE TESTS

- Pyrotek spark plug durability exhibited past the 75 hour mark with std. materials
- Pyrotek contribution is additive to newer technologies (i.e. exhaust aftertreatment, porting, improved fuel control, etc.)
- Pyrotek contribution is independent of air/fuel ratio (tested at a/f of 8:1 up to 17:1)
- Pyrotek spark plug reduces in-use carbon build up, reducing long term HC gain

# PYROTEK BENEFITS

- No additional engineering costs
- No tooling or capital investment
- Small incremental cost
  - Similar cost/benefit ratio to catalysts
- Assists with in-use compliance and emission warranty issues
- Further optimization possible in port or valve timing and catalyst optimization
- Broad retrofit possible to assist in cleaning up the existing population with a simple low-cost spark plug change